SCIENCE FOR GLASS PRODUCTION

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COMPARATIVE OPTICAL CHARACTERISTICS OF SHEET GLASSES

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The paper provides a comparative analysis of the ability of sheet glass produced by different companies to transmit solar radiation in different ranges: 300 – 2500 nm (direct solar transmission), 300 – 380 nm (ultraviolet transmission), and 380 – 780 nm (light transmission). It is demonstrated that a high level of light transmission does not always ensure high ultraviolet transmission.

Among critical requirements imposed on sheet glasses for construction purposes is a high level of light transmission, i.e., the visible component in the solar radiation spectrum of 380 – 780 nm wavelength, although the regulatory documents do not always directly specify the light transmission coefficient, which is specified, for instance, in European standards (EN 572-1:2004, EN 572-2:2004, EN 572-4:2004). The Russian standards used to specify particular values of this coefficient. Thus, according to the standard effective up to year 2001 (GOST 111–90), the light transmission coefficient of 4 mm-thick glass of the best grades M_1 and M_2 (M1 and M2 in the current state standard) has to be at least 88% and in glasses of lower grades ($M_3 – M_8$) at least 85%. The current standard GOST 111–2001 specifies the minimum admissible values of the light transmission coefficient only with respect to glass thickness, without specifying grades (for glass 4 mm thick this coefficient is equal to 88%).

Marketing data on glass necessarily include data on transmission in the visible range of the solar radiation, i.e., light (coefficient of directed light transmission). Besides, producers often indicate solar radiation transmission in a wider wavelength range: from 300 to 2500 nm, i.e., including part of the ultraviolet, the visible, and the short-range infrared spectra. In technical terminology these parameters are called light transmission and solar transmission, respectively.

The transmission coefficient (quality) of glass depends on the level of the technological process and on the quality of raw materials used. The contemporary float glass production method allows for producing glass where the number of defects distorting the course of the rays and decreasing directed transmission is minimal. The leading foreign and domestic manufacturers produce glass that exceeds the standard quality requirements. For instance, 4-mm float glass produced by the Borskii Glass Works, Salavatsteklo JSC, and Saratovstroisteklo JSC actually transmits more than 90% light (which is determined not only by the advanced technology, but also by high-quality initial materials).

It is known [1] that the transparency of glass to visible radiation is due to the fact that chemically pure soda-lime glass has a special structure of lattice and energy zones, in which an intense energy absorption due to electron transitions between the zones (fundamental absorption) starts in the UV range approximately with 300 – 350 nm and on towards increasing quantum energy

$$E = h\nu = h/\lambda,$$

where h is the Planck's constant, ν is the electromagnetic wave frequency, and λ is the wavelength, and, accordingly, toward decreasing wavelengths, whereas absorption due to the lattice vibrations occurs in the IR range starting with approximately 2500 nm and on towards longer waves, i.e., "pure" (without impurities) glass has to be transparent in the range of 300 – 2500 nm. The presence of colorant impurities leads to the formation of additional levels inside the prohibited energy zones and, consequently, to the formation of additional selective absorption bands in the specified interval, whose bounds shift toward its narrowing.

Therefore, the problem of the purity of initial materials in the production of sheet glass is topical. This is especially true with respect to iron impurities, which are virtually always present in quartz sand, feldspar, and dolomite used in glass melting.

Iron in glass can be bi- or trivalent [1, 2]. Bivalent iron ions Fe^{2+} produce an absorption band with a maximum in the range of 1050 nm and thus decrease the clarity of glass in the

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TABLE 1

Manufacturing company	Glass grade	Coefficient, %		
		light transmission	direct solar transmission	UV transmission
Borskii Glass Works JSC	M1	90	84	71
Salavatsteklo JSC	M1	91	85	71
Saratovstroisteklo JSC	M1	91	83	73
Vostek JSC	M5	91	81	66
Simvol Firm JSC	M6	90	79	65
Kvartzit JSC	M6	90	78	58
Proletarii Lisichanskii Glass Works	M1	91	84	68
Gomel Glass Works	M6	90	82	67
St. Gauben Co.	M0	90	81	67
Pilkington Co.	M0	90	82	66

TABLE 2

Manufacturing company	UV light transmission, %		
	initial glass	double glazing (single-compartment double pane)	triple glazing (two-compartment triple pane)
Saratovstroisteklo JSC	73	53	39
Borskii Glass Works JSC	71	50	36
Salavatsteklo JSC	71	50	36
Proletarii Lisichanskii Glass Works	68	46	31
St. Gauben Co.	67	45	30
Gomel Glass Works	67	45	30
Pilkington Co.	66	44	29
Vostek JSC	66	44	29
Simvol Firm JSC	65	42	27
Kvartzit JSC	58	34	20

short-range IR spectrum. Iron in the trivalent form decreases transmission on the short-wave side, since Fe^{3+} produces absorption bands with maxima at 380, 430, and 440 nm and causes an significant shift in the UV transmission bound toward longer waves. Therefore, depending on the quantity of iron in materials used and the ratio between its bivalent and trivalent forms determined by the redox conditions in melting, the level of transmission in glass may vary.

The level of transmission in the IR spectrum is not significant for an ordinary consumer, whereas ultraviolet transmission should be regarded more carefully. In southern latitudes there is an excess of sunshine; accordingly, one can ignore the amount of ultraviolet penetrating through glazing, but in the northern latitudes with a shortage of ultraviolet, in which the major part of Russia is situated, this problem is significant, since a human being (like any living organism) requires a certain amount of ultraviolet radiation for his or her normal vital activity and also for disinfecting building interiors.

The regulatory foreign or domestic standards do not specify the content of the UV component. However, some producers in addition to light and solar transmission indicate the ultraviolet transmission level, i.e., the integral transmission in the wavelength range of 300 – 380 nm.

The Institute of Glass has determined these three parameters for a number of glasses produced by certain domestic and foreign producers. The measurements and calculations of the light transmission coefficient were performed according to GOST 26302–93 and the solar and UV transmission coefficients according to ISO 9050:2003. The obtained data for glass of rated thickness 4 mm are listed in Table 1.

Comparative analysis indicates that the products of leading float glass manufacturers in Russia, such as the Borskii Glass Works JSC, Salavatsteklo JSC, and Saratovstroisteklo JSC, have certain advantages even compared to such renowned world leaders as Pilkington and St. Gauben. Thus, the light transmission in float glasses from the Russian producers is 90 – 91% and the solar transmission 84 – 85%, whereas the same parameters in glasses produced by Pilkington and St. Gauben amount to 90 and 81 – 83%, respectively. At the same time, ultraviolet transmission is higher in domestic glasses: in glasses produced by Pilkington and St. Gauben it does not exceed 67%, whereas in float glass made by domestic producers it amounts to 71 – 73%. This means that only 30 – 45% ultraviolet radiation can pass via double glazing (a double glass pane with a single compartment) made of the former glass, while over 50% ultraviolet is transmitted via the double pane made of the latter glass. In triple glazing these transmission parameters are 18 – 30 and 36 – 39 %, respectively. The level of penetration of ultraviolet into an interior depending on the type of glazing and the UV transmission of the initial glass is shown in Table 2.

The fact that glasses having identical exterior appearance and virtually identical light transition parameters may differ in their optical characteristics with respect to the solar spectrum range which is functionally significant, although invisible to a human eye, has to be taken into consideration by consumers and architects in selecting materials for glazing, especially for living residences, kindergartens, medical institutions, winter gardens, conservatories, and hothouses. The above-mentioned differences in glasses produced by different manufacturers can sometimes help in solving disputes between the customer and the contractor with respect to the origin of glass used in glazing.

REFERENCES

1. M. V. Artamonova, *Structure and Physicochemical Properties of Glass* [in Russian], Moscow (1972).
2. *Reference Book on Glass Production, Vol. 1* [in Russian], Stroiizdat, Moscow (1963).